

WE HAVE NEVER BEEN PRE-DISCIPLINARY**24TH NATIONAL CONFERENCE ON THE BEGINNING DESIGN STUDENT**

Open Section Submission

Abstract / Concrete: the materiality and logics of construction

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Introduction:

The recent technological obsessions fueled by the proliferation of sophisticated structural, environmental, and visual computer simulations have re-ignited the interest in the realm of building performance. However, without a critical understanding of the physical processes of making, these new technologies tend to limit its potential by merely re-affirming the old functionalist thinking: predicting the predictable.

Similar in response to the typical construction technology courses, introduction of these sophisticated digital technologies early in the design education tends to accentuate amongst the average architecture student the “Tech School Mentality.” They are often too concerned with the technical correctness of employing various software, distancing themselves from the opportunities for empirical exploration of design and making. In the design studio, this manifests in a manner where students are eager to meet the minimum “external” requirements (code, program, function etc.) but resistant to creatively explore the “internal” (emotional, experiential) aspect of the design on their own.

This paper contends that the key in evoking curiosity and encouraging the exploratory behavior in architecture students in the digital age is to introduce a material based exploration in a carefully coordinated educational setting. It also discusses the methodology and benefit of integrating the hands-on investigation of concrete into a standard construction technology lecture course and speculates the latent possibility as a mode of design education though the examples from a course taught by the author at College of Architecture, Texas Tech University in the Spring of 2007.

Experience and Education:

“I believe that the active side precedes the passive in the development of the child nature; that expression comes before conscious impression; that muscular development precedes the sensory; that movements come before conscious sensations; I believe that consciousness is essentially motor or impulsive; that conscious state tends to project themselves in action.”¹

¹ John Dewey, “My Pedagogic Creed,” *The Collected Works of John Dewey, 1882-1953, The Early Works*, ed. Jo Ann Boydston, 5 vols, (Carbondale and Edwardsville: Southern Illinois University Press, 1969-1991) 90.

As instructors, we all acknowledge that intellectual learning is not only a function of amassing and retaining information. They becomes “knowledge” only when it is comprehended and internalized.

In his 1933 essay *Education in Relation to Form*, John Dewey, an influential American philosopher and leader of the experiential education movement notes, “Comprehension means that various parts of the information acquired are grasped in their relations to one another - a result that is attained only when acquisition is accompanied by constant reflection upon the meaning of what is studied.”²

He criticized both the traditional educational model (overtly concerned with the delivery of pre-ordained knowledge) and the progressive educational model (overtly concerned with freedom of self expression and individuality) for the lack of respect for the native tendency of the mind towards reflective and truly logical activities at any stage of its development. He goes on to introduce an experience base education model as an alternative along with the Theory of Experience to harness these native tendencies of the mind.

Dewey’s Theory of Experience consists of (2) key concepts: The concept of Continuity and Interaction.

The concept of Continuity refers to the fact that the previous experience will inevitably effect the current experience. It in turn, will effect the future experience. A “domino effect” of experience over time. Dewey states, “Every experience enacted and undergone modifies the one who acts and undergoes, while this modification affects, whether we wish it or not, the quality of subsequent experience.”³ Thus, it is the educator’s business to arrange for the kind of experience that are more than just immediately enjoyable, rather, promotes having desirable future experience.

The concept of Interaction refers to the fact that the objective (external) and internal conditions are equally important factors in an experience. This seemingly obvious concept is important for Dewey in distinguishing the traditional mode of education from the progressive mode of education. The former emphasizes only the transmission of external, pre-ordained knowledge and does not consider the internal experience of the student at all.

The goal of an educator, according to Dewey is fostering experiences that encourage good habits, growth (physical, intellectual, and moral), positive interaction, and knowledge or

² John Dewey, “Education in Relation to Form,” *The Collected Works of John Dewey, 1882-1953, The later Works*, ed. Jo Ann Boydston, 8 vols. (Carbondale and Edwardsville: Southern Illinois University Press, 1969-1991) 176.

³ John Dewey, *Experience and Education*, (New York: The Macmillan Company, 1938) 26-27.

skills that become instruments of understanding in dealing effectively with situations to come. In other words, good educational experience is a well conceived positive experience, which ensure positive future experience that leads to the better preparation for life-time appreciation, independence, and development.

Teaching Methods:

The typical educational method in a design studio setting is by default empirical in nature. Students are expected to form individual approaches to architectural solutions through production (drawings and models) and critiques under the personal guidance of an instructor. This is one of the most valuable aspects of architectural education, not only from the perspective of acquiring design skills but also from a more general effect to the personal growth and maturity of the students.

However, this is not necessary the case with construction technology education. These courses generally follow the traditional mode of education, structured to emphasize efficient transmission of pre-ordained knowledge with minimum effort of the instructor to a maximum number of the students. Due to the amount of information required to be covered in a set period of time, it is often devoid of any authentic experiences concerning the actual materials covered in the course. How can we integrate the experiential in these courses?

The embodied knowledge of making is gained through the physical interaction with materials, searching for an order rooted in history, perception and materiality. ARCH3356 "Special Studies in Construction Technology" course taught by the author in the spring 2007 at Texas Tech University, College of Architecture encouraged students to develop an innate understanding of relationships between the materiality and logic of construction through the exploration of concrete and its tectonic possibilities. (37) Students were enrolled in this course.

As an architect, it is unsatisfying to teach a technology course just to impart knowledge of generic, risk adverse, industry standard construction details without any consideration of the materiality and the implications of tectonic design. Simulation through digital modeling and quantitative structural analysis has possibilities for tectonic exploration. However, ignoring the complexities of the physical qualities such as mass, weight, balance, material tendencies, texture, scale, surface quality under various lights, weather conditions, and time will subordinate the materiality to digital mapping on a surface, an appliqué. Without a link to physical making, this effectively reduces the tectonic exploration into exploration of form. The course provides an opportunity for students to systematically confront the material, concrete.

Modes of Investigation:

The course was modeled after typical undergraduate level experimental physics courses from the authors personal experience. (3) distinct modes of investigation were employed: theoretical / historical, physical / perceptual, and precedence research in lieu of data analysis and conclusion.

The “theoretical” examined the history and theory, including basic quantitative engineering methods behind the property and development of cement and reinforced concrete in traditional lecture format.

It begun with the discussion regarding the origin and evolution of the concept “Tectonics” and arrived at our own definition for the course: Logic of materials and its inherent potential for architectural expression as an assembly. Examples of tectonic implications of the materials were presented. Definition and historical evolution of concrete as a material followed. The emphasis was placed not only on the scientific facts of the material itself but also on the political, economical, cultural and geographical influences which shaped the market for the emergence of such new industrial material. Then, the concept of reinforced concrete, its historical development and tectonic application were introduced prior to engaging in the basic quantitative engineering methods on composite material design. Looking at the development of the material from a historical and cultural perspective, I believe, gave a more complex and nuanced understanding of the technology as a result of human activities. Each lecture was accompanied by a short quiz to provide an opportunity for reflection and to check the students’ level of comprehension. To conclude the lecture, advanced studies on concrete technology was discussed, including experimental works done at The Center for Architectural Structures and Technology at the Faculty of Architecture, University of Manitoba under the direction of Prof. Mark West. I’d like to acknowledge his generous contribution regarding the latest developments at the C.A.S.T.

The “physical” examined “the making” of concrete panels and documenting them in various natural lighting and weather conditions (equivalent of data collection). Each student produced a minimum of two (24”x36”x2”) concrete panels by designing and constructing formwork. They used various materials and methods including basic digital fabrication techniques. The students were randomly assigned into groups of (5) to collaboratively mix and cast concrete. Under supervision of the instructor, each group had (3) opportunities to “pour” during the regular class session.

The “precedence research” consisted of a comparison of a pair of buildings constructed with unique applications of concrete. The research was performed as a group project, parallel to the concrete panel fabrication, culminating in a digital media presentation. It allowed students to begin speculating the tectonic application of the concrete panels they have fabricated. Due to the technical nature of the course and schedule limitation, in order to foster the “future positive” experience, studying appropriate precedence seemed more effective than embarking on an individual design projects exploring the tectonic possibilities of concrete panels.

Concrete as a material:

Ubiquitous yet rich in process, concrete is an ideal material for creating an effective empirical learning experience. It is one of the few materials where manufacturing is required on site via proportioning and mixing of the cement, aggregates, and water under various weather conditions. These subtle variables influence the outcome of the workability,

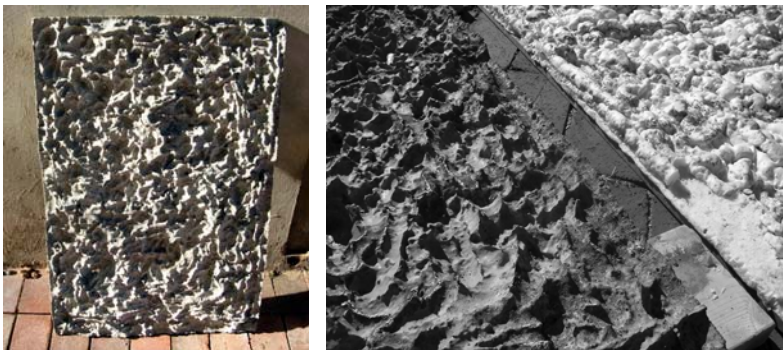
strength and surface quality. The material exhibits the property of liquid when poured and the property of solid when cured providing little margin for any correction. Combined with the substantial density/weight, it resists control without proper consideration for gravity. The material is infinitely scalable with rich color, texture and surface quality. Construction of required formwork implies the dichotomy of negative and positive relationships, retaining the memory of the formwork. A level of imprecision in the outcome resisting predictable human manipulation results in the distinct tectonic possibilities. Also, having been a recently rediscovered material, historical development and its creative applications are well documented.

Concrete Panel Casting Outcome:

Students were encouraged to experiment with the fabrication of the concrete panels. No design sketches or mock-ups were required. Technical advice was provided on an individual basis. No critiques regarding esthetics were given as per nature of the course. A recovery from a spectacular failure was emphasized over a mediocre, predictable success. The enforcement of this simple principal freed the students from the burden of the predetermined notion of success and fostered unique, unexpected methodologies and results. The absence of preexisting expectation seemed to have been a positive asset as students relied on their native common sense and power of judgment.

Example 1: Texture - performance of unique material

Student: Dixon



The formwork was made of spray-on polyurethane insulation foam. The flexible, rubber-like quality of the foam allowed for the removal of the formwork without taking away the minute details.

Example 2: Pattern - unexpected use and performance of common material

Student: Guerin



Formwork made of a colorful marble like substance was “caught” in the concrete. Left exposed in the rain and snow for a few days, the marble like substance, which turned out to be “gum-balls” dissolved away and left the voids on the concrete surface.

Example 3: Texture - unique application and performance of common material

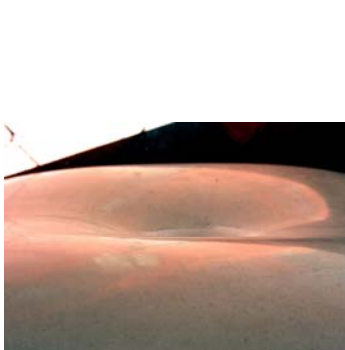
Student: Faulkner



Concrete was poured over wood-chips laid over the surface of the formwork. Lighter fluid was doused over the wood-chips and burned away. The ashes were carefully brushed away. Remnants were washed away by the subsequent snow and rain.

Example 4: Fabric formwork - post tensioning

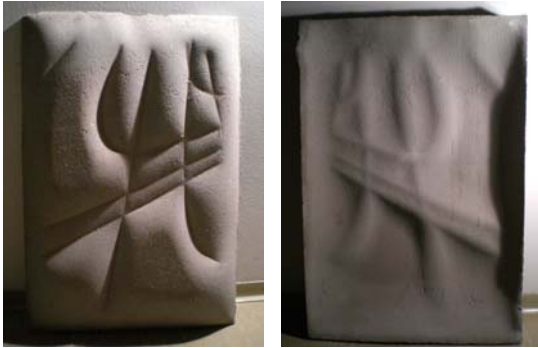
Student: Musset



A vinyl sheet was tightly stretched over the frame and was post tensioned at the center after the concrete pour. This resulted in deformed surface on both sides of the panel. The smooth, impermeable surface of the vinyl resulted in glassy, reflective concrete surface.

Example 5: Fabric formwork - negative / positive

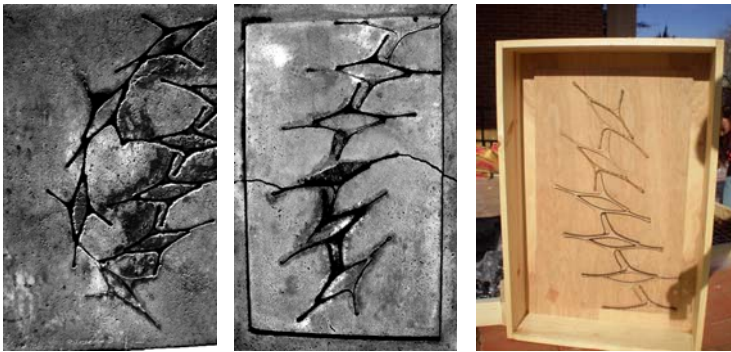
Student: Slingerland



A cotton muslin was stretched over the bent metal bars fixed across the frame. Concrete was poured over the fabric for the initial cast. The resulting cast was used as a positive mold to cast a negative cast.

Example 6: Digital fabrication - laser cut

Student: Wester



Intricate patterns created by repeating units were laser-cut and laid in to the form.

Precedence Research Outcome:

The precedence research paralleled the fabrication of concrete panels. A pair of concrete building was randomly assigned to each group early in the semester. (2) Weeks were assigned to complete basic research to collect the following information and upload the data in PDF format to the designated server folder for instructors review and input.

- a.) Basic Project Data of the buildings - Location, Client, Architects, Landscape Architects, Other Collaborators (if any), Engineers (structural, mechanical, civil etc.), Contractor and/or Construction Managers, Project Design Date, Project Completion Date, Built Area
- b.) Bibliography of reference books related to the buildings
- c.) Collection of web pages and images related to the buildings
- d.) Outline schedule to complete the research and put together the presentation

In order to form a educational collaborative environment, the roll of each individual within the group was discussed and determined during the class based on the following guide-lines:

Select a project manager (PM). The project manager is the organizer of the team, responsible for assigning specific tasks to the team members and keeping track of their activities to ensuring the timely completion of the project. For this assignment, The PM will assume the following responsibilities.

- 1.)Assign research and writing tasks to the members.
- 2.)Lead the discussion and establish consensus regarding the presentation concepts.
- 3.)Organize research information and images gathered by the team and assemble them into packages for other team member(s) to put it into digital presentation.
- 4.)Responsible for uploading the research materials to the server
- 5.)Organize the presenter(s) for the presentation (everyone in the group must present a portion)
- 6.)Tweak the digital presentation if necessary.

Team members are responsible for carrying out the assigned tasks as required and to support the PM to accomplish the project in an efficient manner.

Example 1:

The Sydney Opera House, Jørn Utzon / The Eberswalde Technical School Library, Herzog & de Meuron

Students: Mussett(PM), Guerin, Hanson, Houlette, Wester

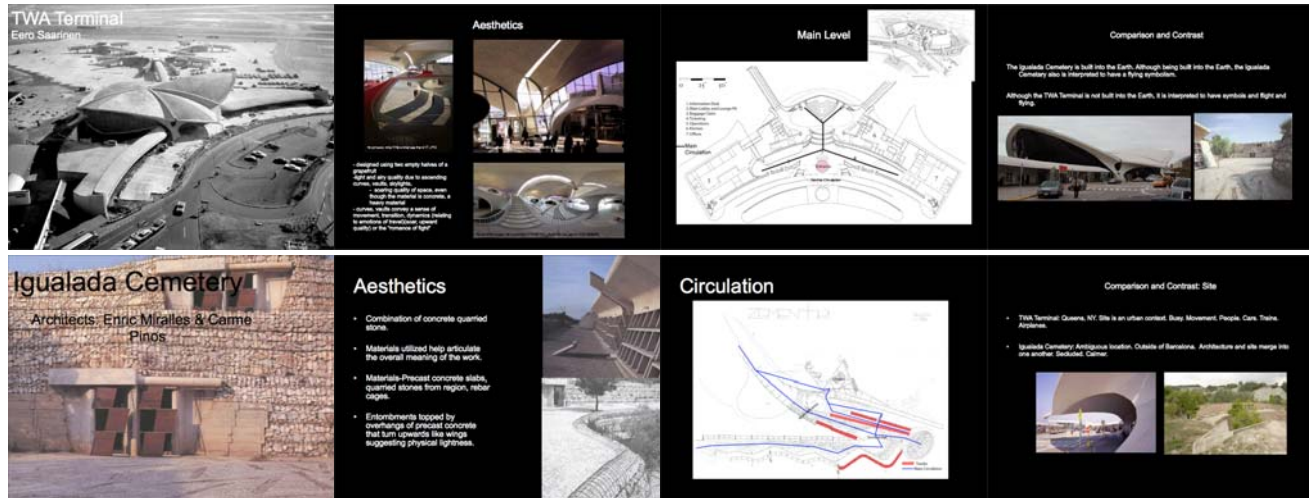


The presentation compared the technique and ideas behind the precast exterior panels.

Example 2:

TWA Terminal, Eero Saarinen / Igualada Cemetery, Eric Miralles, Carmen Pinos

Students: Penner(PM), Bartholomew, Carter, Dorris, Kuxhausen

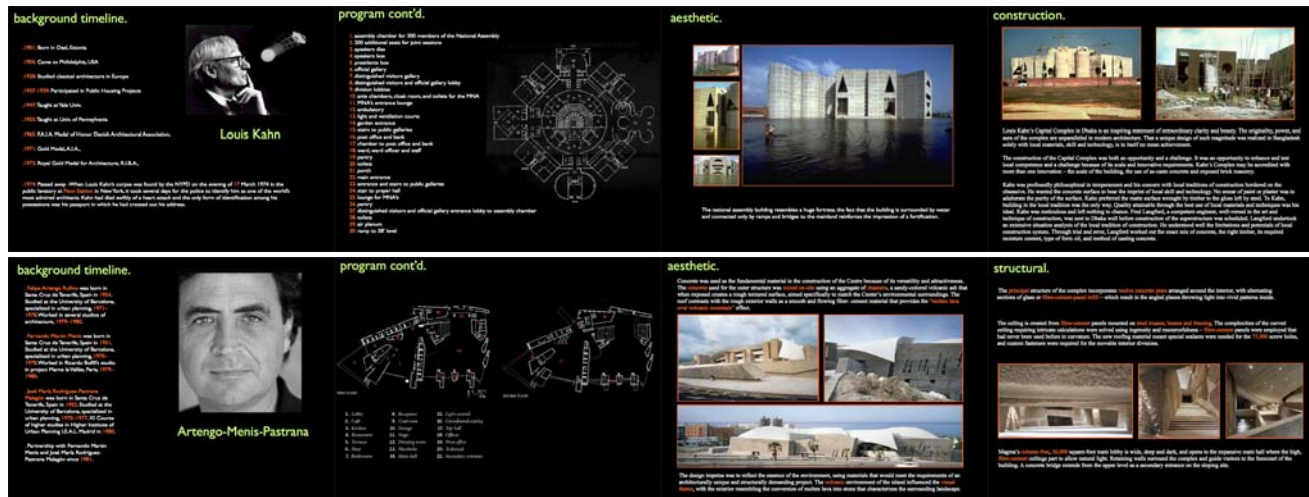


The presentation compared the metaphorical ideas behind “flight” and “weightlessness” of concrete.

Example 3:

National Assembly, Dhaka, Louis Kahn / Magma Arte and Congresos, Artengo-Menis-Pastrana

Students: Quinonez(PM), Larriva, Cruz, Slingerland



The presentation compared the integration of local materials and labour and its tectonic implications.

Speculation:

“Modes of thought, of observation and reflection, enter as forms of skill and of desire into the habits that make a man an engineer, and architect, a physician, or a merchant.”⁴

⁴ John Dewey, *Democracy and Education*, (New York: The Macmillan Company, 1916) 57.

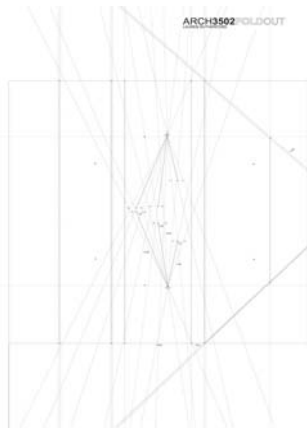
“Thought or reflection is the discernment of the relation between what we try to do and what happens in consequence.”⁵

What is an effective method for the students to reflect upon what they have just fabricated? As Dewey points out, opportunity for reflection is a key component of effective education. The course did not attempt to deal with this question directly for the same reason why no official feedback was made regarding aesthetics of the concrete panels. Instead, it focused on forming habits to observe through photo-documentation. In some ways, the course was successful in getting students to think “outside of the box” precisely because the exercises focused on the “habit forming” positive experience. They were released from the expectation and anxiety from being externally forced to think constructively. Emphasis on opportunity for reflection may not exactly be suited in this particular context.

Perhaps, the best way to address this question is to speculate how we can integrate the material and tectonic base investigation into design studio environment as a useful learning experience. As discussed earlier, design studio education is inherently empirical. The key tool which stabilize this dynamic process and allows moment for reflection crucial to creating effective learning environment is the notational drawings (not pictorial) - plans, sections, elevations and details. The drawings not only function as a medium to visually communicate ideas but also as a tool for analysis and finally as a record of operations. Drawing as a medium for recording measured operations can be most potent when combined with material base investigations. It provides much needed moment for reflecting upon the operations the student has undertaken and to revise subsequent operations based on the previous outcome. The following examples are from the on-going investigation conducted in the authors performance base design studio ARCH3502 in Spring 2008.

Example:

Student: Rutherford



⁵ Dewey, 169.



Students were asked to design and construct a formwork out of a single sheet of (45"x45") natural, unbleached cotton muslin without any cuts and to vertically cast a solid concrete "deformed column" with a maximum outer dimension of (10"w x36"h) thickness of (2" +/-). The use of a plywood sheet backing in conjunction with washers, nuts and bolts to restrain the fabric formwork against the hydrostatic pressure of the concrete was suggested. This allows post tensioning of the fabric formwork during or immediately after the pour. Students were encouraged to consider articulating the surface of the deformed column with pleats and folds however, were restricted to a single (80) pound bag of pre-mixed concrete per pour to take the overall volume of the deformed columns into account. After the initial cast, they were asked to focus on a specific aspect of the cast and construct another fabric formwork. In conjunction with this exercise, they were asked to construct a "fold-out" record drawing of the fabrication of the formwork based on a suggested notation system recording every operation made on the surface of the fabric. This drawing became a "working drawing" for the design and cast of subsequent deformed columns. Any changes made were layered over the drawings to track the design changes, allowing them to contemplate and reflect on the processes.

The "record drawings" also presents a secondary benefit, an opportunity for interpretation and transformation. The drawings are a record of type, location and duration of "actions" in relation to each other and to the surface of the fabric, not a pictorial depiction of the final product. It implies scalable and interpretable opportunities as operations to other types of architectural surfaces including a site, linking the technological application of the material with building and site strategies.

Based on the theory of experience, Dewey discusses how the developmental methods begins with consideration of the prior experience of the student. The role of an educator is to arrange and sequence the materials and to create a learning environment that is most effective. Between a direct material investigation and strategy for recording the operations as drawings, it is possible to imagine an architecture design studio dealing with the issue of materiality and the logics of construction. The construction technology course previously discussed is an ideal set up in the support of such studio experience.

Conclusion:

“Deliberation (inquiry) is a dramatic rehearsal (in imagination) of various competing possible lines of action. It starts from the blocking of efficient overt (habitual) action, due toconflict.”⁶

“More ‘passions,’ not fewer is the answer.... Rationality..... is not a force to evoke against impulse and habits. It is the attainment of a working harmony among diverse desires”⁷

The above remarks by Dewey suggest that passion and development of a creative imagination are every bit as important as acquiring a mastery of facts and principles of logic. Students, partial to the representational mode of architectural investigation through virtual modeling and visualization were, for the first time, systemically introduced to confront, experience, and embody the reality of basic material and the scale of construction within the carefully calibrated course structure. The positive experience dealing with the rich properties and possibilities of concrete “on their own terms” nurtures and prepares the students with inklings to creatively deal with any construction material in the future. I believe that this fundamental perceptual shift will have a significant impact on the development of beginning design students, complementing the ever more sophisticated simulated design environments.

⁶ John Dewey, “Human Nature and Conduct,” *The Collected Works of John Dewey, 1882-1953, The Later Works*, ed. JoAnn Boydston, 14 vols. (Carbondale and Edwardsville: Southern Illinois University Press, 1969-1991) 132.

⁷ Dewey, 136.